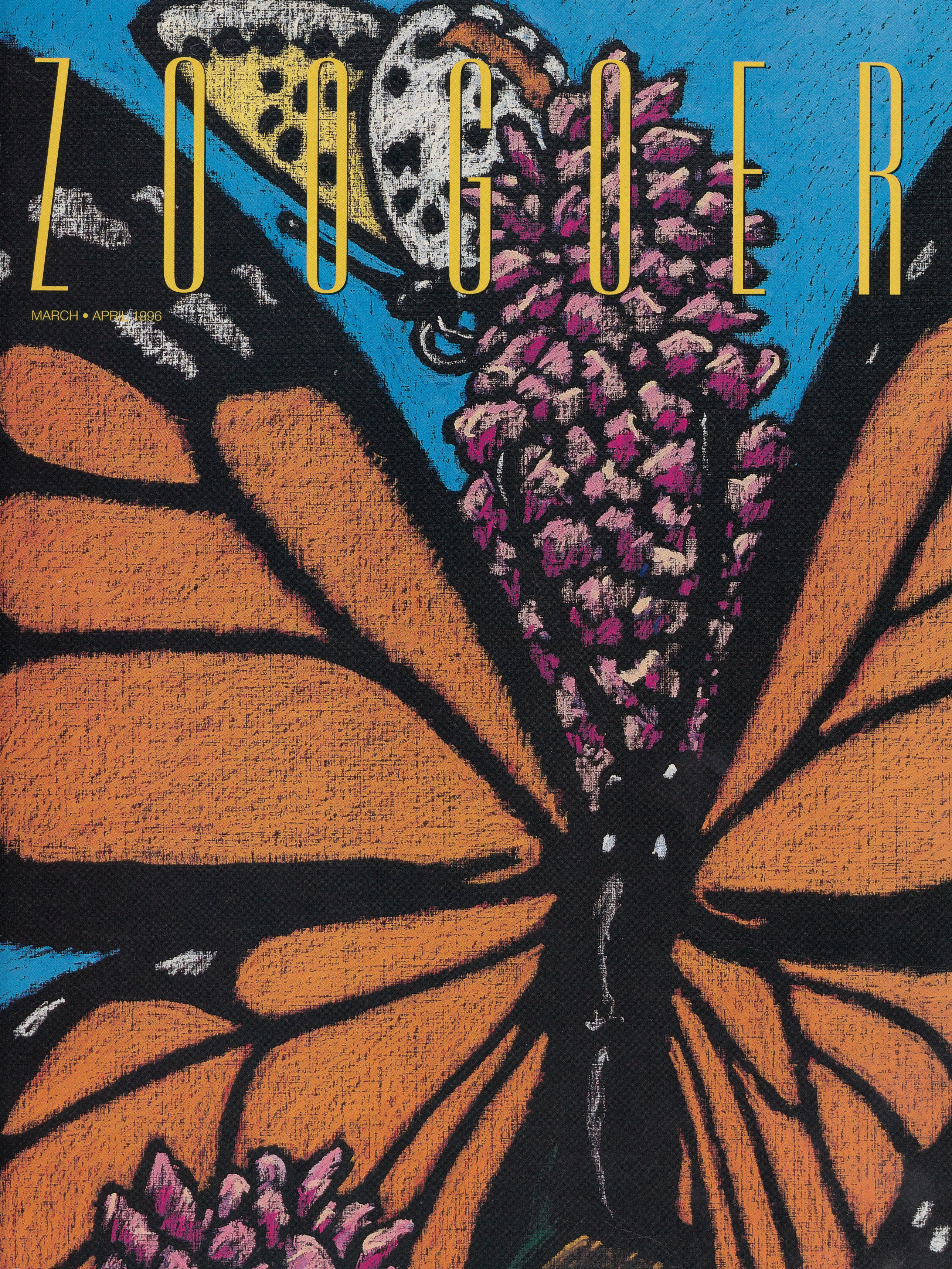
ZOOGOER

MARCH • APRIL 1996



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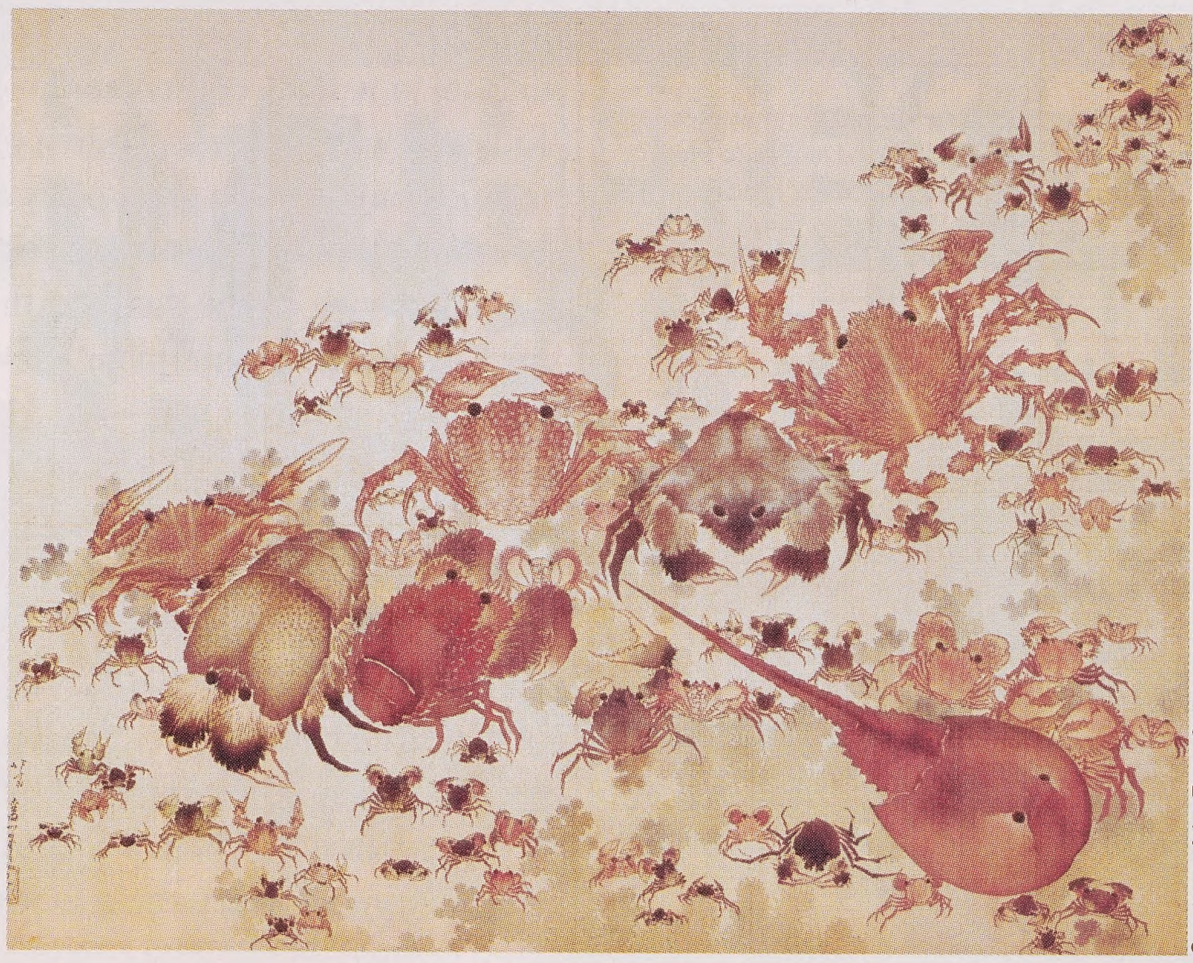

Courtesy of the Freer Gallery of Art, Smithsonian Institution, Washington, D.C. (02.254)

Crustaceans dominate the seas much as insects rule the land, ranging in size from microscopic copepods to giant spider crabs, with legs that span more than 10 feet. The painter Hokusai painted some crab species familiar in Japan, and also included an animal often mistaken for a true crab, the horseshoe crab. This work was painted between 1760 and 1849, during the Edo period.

SPECIAL ISSUE: INVERTEBRATES

6 LEPIDOPTERANS: ALLURE AND ILLUSION

Familiar to everyone, well-known to few, butterflies and moths lead dangerous lives, and many must employ startling or stealthful strategies to foil their many predators.

11 INVERTEBRATES: THE MARVELOUS MAJORITY

They're everywhere, and in many respects they rule the world. Learn more about the bizarre and fantastic world of creatures without backbones.

DEPARTMENTS

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NOTES & NEWS

A look ahead to two ZooFaris: Caterpillar Crawl and Butterfly Fest, and a call for volunteers.

Friends of the National Zoo

is a nonprofit organization of individuals, families, and organizations who are interested in helping to maintain the status of the National Zoological Park as one of the world's great zoos, to foster its use for education, research, and recreation, to increase and improve its facilities and collections, and to advance the welfare of its animals.

ZooGoer [ISSN 0163-416X] is published bimonthly by Friends of the National Zoo to promote its aims and programs, and to provide information about FONZ activities to its members, volunteers, and others interested in the purposes of FONZ. Third class mailing permit no. 6282. Copyright 1996, Friends of the National Zoo. All rights reserved.

The National Zoological Park is located in the 3000 block of Connecticut Avenue, N.W., Washington, D.C. 20008, 202-673-4717. Weather permitting, the Zoo is open every day except Christmas. Hours: From October 16 to April 14, grounds are open from 8:00 a.m. to 6:00 p.m.; buildings, 9:00 a.m. to 4:30 p.m. From April 15 to October 15, grounds are open from 8:00 a.m. to 8:00 p.m.; buildings, 8:00 a.m. to 6:00 p.m.
Director: Michael H. Robinson.

Membership in FONZ entitles you and your family to many benefits: publications, discount privileges, and invitations to special programs and activities to make your zoogoing more enjoyable and educational. To join, write FONZ Membership, National Zoological Park, Washington, D.C. 20008, or call 202-673-4960.

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There's no better party in Washington, perhaps anywhere, than National ZooFari, FONZ's annual fundraiser for the National Zoo. One hundred of Washington's finest restaurants, some of the best in the world, serve glorious food. Music rocks parts of the park, mellows out others, and this year, a concert by The Spinners tops off the evening. Party-goers vie for gifts and trips in a sweepstakes and silent auction. Others stroll under the stars for rare nocturnal meetings with the Zoo's exotic animals. And others simply dance the night away. But National ZooFari is definitely an adult affair.

So this year, for the first time, FONZ also invites you to its first annual ZooFari for Kids—a fundraiser with activities, entertainment, and food just for kids and their families.

At Friends of the National Zoo, we know that many kids today look for ways to participate in wildlife conservation—to make a difference. So we conceived of ZooFari for Kids as a way for these children to make a contribution to a favorite conservation organization, and enjoy a great party at the Zoo at the same time! ZooFari for Kids will benefit education programs at the National Zoo.

And playing on the theme of this year's National ZooFari—Butterfly Fest—ZooFari for Kids will be a Caterpillar Crawl, set for Friday, May 10, from 6 to 8 p.m. Even the ticket prices are pint size—just $12 for FONZ members and $15 for the general public, and that's all-inclusive!

Caterpillar Crawl will offer non-stop, action-packed fun for kids ages 2 to 12. There will be merry-go-rounds, pony rides, magicians and jugglers, singers and dancers, moon bounces and trampolines, and lots more super stuff for kids to do. Our littlest guests will enjoy the the Toddler Play Zone. Food will include burgers, hot dogs, pizza, and other kids' favorites, not to mention ice cream cones and cotton candy. And we will offer some menu choices for parents as well as a cash bar.

The greatest supporters of National ZooFari are you, the members of FONZ, and I am counting on you to help us make ZooFari for Kids a success. The need has never been greater. As the Zoo continues to grapple with downsizing and federal budget cuts, the funds raised at these events are ever more important to the Zoo. Proceeds will go toward exhibition, conservation, education, and research programs at the Zoo.

Both Butterfly Fest and Caterpillar Crawl highlight butterflies and the hundreds of thousands of lesser-known members of the invertebrate world. Both celebrate the opening of Pollinarium, a new wing of the Zoo's innovative Invertebrate Exhibit. Pollinarium brings to life the complex and fascinating relationships between plants and their animal pollinators—butterflies, bees, and other invertebrates, as well as hummingbirds—in a lush garden of fragrant, colorful flowers. Everyone—kids and adults alike—who visits Pollinarium will come away with a new appreciation of the natural world, the kind of appreciation necessary to inspire people to want to save it.

I'm an optimist. I hope you will come out for the Caterpillar Crawl on May 10, and return on May 17 when the party metamorphoses into a Butterfly Fest! But if you can't attend both events, please do attend one. Either way, you will be supporting the Zoo—and enjoying a great party at the same time.

Sincerely,

Clinton A. Fields
Executive Director

For more information on Caterpillar Crawl and Butterfly Fest, see page 30.
For tickets call 202.673.4961.

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lepidopterans: allure and illusion

michael h. robinson

If all of the ants in the Amazonia forest were lumped together, their mass would be greater than all of the land-living amphibians, reptiles, birds, and mammals combined. In fact, insects dominate the land everywhere both in numbers of species and numbers of individuals. Insects are present in all major ecosystems and habitats with the notable exception of perpetually frigid areas and the seas and oceans. There, their crustacean cousins are the dominant arthropods, a group that comprises all the animals with a jointed exoskeleton, from tiny mites to giant crabs, and including spiders, the great slayers of insects.

Edward S. Ross

Bold coloration, like the gaudy bands on this hawkmoth larva from Ecuador, usually warns would-be predators that the color-bearer is not a tasty meal.

Among the multitudinous insects, the Lepidoptera—butterflies and their mainly nocturnal close kin, the moths—stand out as a relatively well known and highly successful group, with more than 125,000 species so far described. Butterflies and moths are conspicuous flyers in many parts of the world. In general, butterflies and moths are fairly slow-flying flutterers, but some are quite swift on the wing, and some are fast enough to elude birds and bats in flight. Many adult butterflies and moths are large and brightly colored, beautiful creatures that visit flowers for food and do good in their role as plant pollinators. But first impressions, based on the familiar members of this group, are misleading. Not all lepidopterans are brightly colored, not all are large as insects go, and not all are flower visitors as adults. Some are quite dull in color, as camouflage against predators, while others disguise themselves as leaves or even bird droppings. Some are tiny—about the size of a sesame seed—while the birdwing butterflies, with wings that would cover both pages of this magazine, are the largest known insects. In rare cases, some butterflies ignore flower nectar and drink tears and blood instead.

The larvae of butterflies and moths are known as caterpillars. These tubular creatures, sometimes fuzzy, sometimes bearing strange spikes, sometimes garishly colored, often provide children with their first memorable encounters with as odd an animal as an invertebrate. Unlike the mostly benign adults that they turn into, most caterpillars feed on leaves and can be relentless plant pests. The massive defoliation wrought by gypsy moth caterpillars

is a perfect example. On the other hand, the caterpillars of the silk moth—silkworms—are the only domesticated insects and provide one of our most luxuriant and prized fabrics. Silkworms are raised on mulberry leaves and spin the precious silk to form the cocoon that encloses the pupa (the stage in a lepidopteran's life cycle before the adult butterfly or moth emerges).

cases of mistaken identity

If a butterfly or moth is large, conspicuous, and slow flying, the risks of predation are great. Butterflies are eaten by birds, lizards, spiders, and a wide range of other insects. Haunting the night skies, moths are pursued by bats and trapped by spiders. To defend themselves, some butterflies are downright nasty. Monarchs, for instance, taste terrible and make birds that eat them vomit violently. The compounds, called cardiac glycosides, responsible for this effect actually come from the plants on which monarch caterpillars feed. These chemicals are part of the defensive system of milkweed, although they don't seem to deter the caterpillars, which eat the leaves, store the chemicals, and pass them along to the adult form. Birds, however, associate the butterfly's conspicuous orange and black coloration with their traumatic experience and avoid encounters with monarchs thereafter. (Animals, including these butterflies, coral snakes, and dart poison frogs, that advertise their nastiness with memorably vivid colors that are conspicuous even to our eyes are said to be warningly colored.)

Edward S. Ross

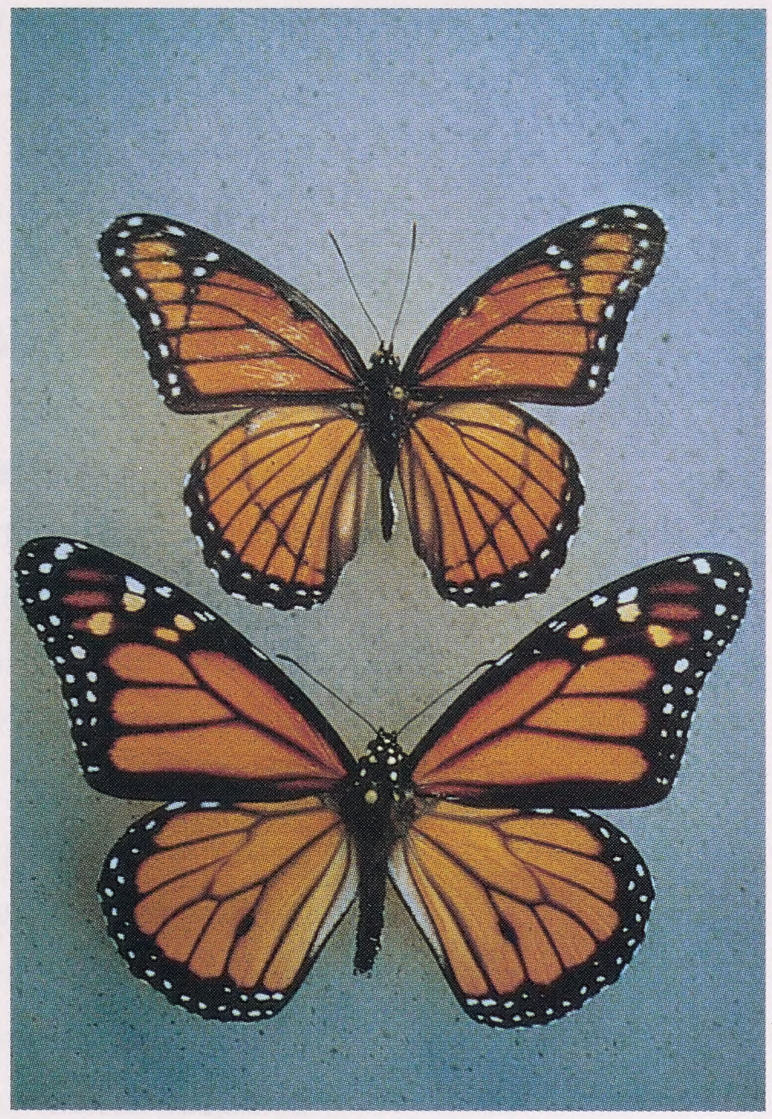
False or "pictorial" eyes on the hind wings of this moth startle or drive off attackers. Literally thousands of species of insects, as well as frogs and birds, use a phony eye trick.

As so often happens in nature, there are some cheats that cash in on the monarch's defenses. Harmless themselves, viceroy butterflies look like monarchs and so are avoided by birds. In some butterflies, the match between the harmful species and the cheating, harmless one is uncannily exact, with color and pattern identical down to the last detail. The benefit to the cheater, of course, is protection from predation without the expense of producing or storing poison itself.

This type of deception was first illuminated by English naturalist Henry W. Bates, a butterfly and beetle enthusiast. In 1863, at the age of 22, Bates embarked on an exploration of the Amazon that was to last 11 years. From this adventure came a marvelous book, *The Naturalist on the River Amazons*, and the immortalization of his name: When a harmless animal mimics a harmful one, it is known as Batesian mimicry. He also collected specimens of more than 14,700 species of animals, almost 8,000 of them new to science. A testament both to his interest and their

abundance—some 14,000 of the specimens were insects!

Mimicry is not limited to resembling other, poisonous species. To avoid predation, some butterflies are marvelously convincing mimics of leaves, even folding their wings together when at rest so the markings on their undersides look like leaf veins. Other butterflies and moths have paired wing markings that resemble eyes. These may be paired on hind wings and closely resemble owl's eyes, complete with oval pupils and owlish highlights. Hidden when the moth is at rest, the sudden flash of the eyes startles approaching would-be predators, giving the insect time to escape. Small eye markings on wing edges appear to deflect the bites of pursuing predators from the vital head and thorax. Some species of hairstreak butterflies go a step farther: the edges of their hind wings form a false head, which even has fake antennae to catch a predator's attention. Losing a bit of expendable wing is much better than losing one's head!



Edward S. Ross

The viceroy (top) usually avoids predators because its coloration and markings are so similar to those of the nasty-tasting monarch (bottom).

masters of danger and deception

Caterpillars also have their defenses, including warning coloration. This is the most vulnerable stage in the lepidopteran life cycle, as caterpillars are slow and often highly exposed on the leaves they eat. Some caterpillars cause intense skin irritation in mammals. I still remember the rash on my arms and legs that broke out after I handled a hairy black and red caterpillar when I was eight years old. It was agony! After that, I knew that black and red meant danger. The caterpillars of saddleback moths look cute, rather like small terriers wearing doggy jackets. They have lateral rows of stiff spines and four long projections, fore and aft, bearing clumps of spines. Merely brushing against the spines causes instant pain like an electric-shock jolt, presumably from some very potent substance.

The caterpillars of many species of swallowtail butterflies are equipped with a special pair of protrusible processes on their heads that release an extraordinarily malodorous substance. When provoked, for example by a pecking bird, the two yellow horns appear, along with an overpowering smell of sweaty socks. Many swallowtail caterpillars rest in clumps of up

The colorful patterns and spines on the saddleback caterpillar warn predators that tangling with this moth larva could mean trouble. Humans suffer painful stings from holding this and many other bristly caterpillars.

Rob Simpson

to 20 individuals. When they stink simultaneously, the smell is detectable many feet away.

Other caterpillars exhibit a range of camouflage defenses. One of these is counter-shading, a device that reduces the outline-enhancing effects of highlight and shadow. Most solid objects lit from above look solid to us because the top is highlighted and the bottom in shadow—think of how artists convey this by shading. Caterpillars that feed on the tops of leaves have light-colored underparts that cancel out the shadow and dark backs that cancel out the highlight. In caterpillars of species that habitually feed on the undersides of leaves, however, this counter-shading is reversed. Many camouflaged caterpillars are barred or blotched like the clothing of a soldier or hunter.

Michael H. Robinson

The counter-shading on this large moth caterpillar ensures that when light hits it, the top still appears dark, while the lighter underside is in shade. The overall effect is to subdue the colors so the vulnerable larva blends in better. This species, related to North America's royal walnut moth, was photographed in Panama.

Other caterpillars disguise themselves as a defense. For example, bird-dropping mimicry is fairly common. In some swallowtail species the caterpillars are white with green blotches and have the slimy look of fresh bird feces. Some caterpillars even change their disguise as they molt and grow. First they rest on leaves and mimic feces; at a later stage, when they move to stems, they mimic bark. Others are stick mimics, such as the inchworms that clasp twigs with their posteriors and hang away at an angle like small side branches. Experiments with insect-eating birds show that they usually do not detect immobile stick mimics but eat them instantly if they move.

Another caterpillar defense is snake mimicry. Several kinds of moth caterpillars respond to disturbance by inflating the front of their bodies into snake-like heads, complete with large imitation snake eyes. Thus transformed, they twitch from side to side in a startling manner. We have no experimental proof that this works with natural predators, but it surely scares naive humans! Similarly, hag moth caterpillars, sometimes called monkey slugs, look like hairy spiders, complete with pseudo-legs.

Hag moth caterpillars may even scare their parents away, as spiders are important butterfly and moth predators. Web-building spiders, especially nocturnal ones, set their traps for moths when they are potentially a rich food source. But moths, and, to a lesser extent, butterflies as well, have a non-stick or slippery defense. Wing scales are powdery structures that slip easily off the wings. When a moth or butterfly strikes an orb spider web, the scales stick to the web's gluey droplets and the moth or butterfly does not. In turn, spiders have evolved various specializations to increase their moth-trapping ability. The ultimate spider weapon,

found in bola spiders and others, may be synthesizing a copy of a female moth's sex attractant perfume. This lures male moths to their doom.

Lepidopteran marvels abound.

Michael H. Robinson is the Director of the National Zoo.

Most adult butterflies and moths feed on nectar, but there are species that feed on the juices of decomposing organic matter, both plant and animal, others that sip tears from the eyes of vertebrates, and even some that suck the blood of mammals. Similarly, caterpillars are primarily plant eaters, but some eat flowers or ant larvae and pupae, and others eat dung. Dung eating brings up perhaps the most bizarre moth/mammal relationship known. Adult sloth moths—up to a hundred or more—live on the fur of two- and three-toed sloths. Sloths, as leaf eaters, retain the difficult-to-digest leaves in their gut for many days, giving bacteria time to break down the leaves' cellulose into starches and sugars. As a result, defecation takes place only at weekly or longer intervals. The feces, however, are a rich food resource for sloth moth caterpillars. When the sloth descends to the ground to defecate, gravid moth females leave the sloth to lay their eggs on the fresh dung. Riding on the sloth ensures that the female moth is around at those rare and short moments when the caterpillar food is voided.

—*Michael H. Robinson*

Jessie Cohen/NZP

More than one hundred moths may hop a ride on a sloth, waiting for it to defecate.

invertebrates: the marvelous majority

While everyone is familiar with butterflies and moths, these diverse insects constitute just a small fraction of invertebrate species. Invertebrates are the most abundant creatures on earth, crawling, flying, floating, or swimming in virtually all of earth's habitats, from townhouses to tropical rainforests. Yet most of us rarely notice them unless they're in our gardens or on our dinner plates.

Invertebrates—the many creatures without backbones—are nature's unsung heroes, quietly playing vital roles in earth's ecosystems. Swarms of krill feed whales and people, coral reefs provide homes for a quarter of all marine fish species, and tiny wasps and other predators stalk some of our most formidable pests, and control others so effectively that they never reach pest status. Invertebrates can also be among humanity's worst enemies. Locusts, corn borers, and other agricultural pests cause billions of dollars in crop damage each year, and some of the world's most deadly diseases are transmitted through some invertebrate species. Yet invertebrates also inspire us, and appear widely as subjects in our art and literature, having wormed their way into the hearts of some of the world's most accomplished writers and thinkers. Some examples of invertebrates in literature punctuate this article.

howard youth

All told, perhaps 99 percent of all known living species are invertebrates. Vertebrates—fish, amphibians, reptiles, birds, and mammals—make up but a tiny fraction of life on earth. You need not go farther than the National Zoo's Invertebrate Exhibit to encounter some of the world's most striking invertebrates. In fact, more than a quarter of the animals featured in this issue (those marked with a ★) reside there. This issue provides a small glimpse at the astounding and diverse world of invertebrates, but once you've been bitten by the invertebrate "bug," you'll notice many more creatures all around you. All you need to do is start looking.

invertebrates

Paul H. Humann

jellyfish

Jellyfish tend to drift with currents. However, many deliberately move by pulsing their cap-like bodies. Most jellyfish catch prey by stinging, paralyzing anything that gets tangled in their tentacles. Each year, jellyfish migrate up the Chesapeake, reaching the farthest north in years of high salinity, when scanty rain fails to flush out rivers flowing into the Bay. These familiar jellyfish, called sea nettles, grow to only about 18 inches long. The largest jellyfish, fortunately, never strays into the Bay. The largest specimen, a giant jellyfish native to cold northern seas, was recorded to be 120 feet long, with a cap, or medusa, measuring more than seven feet wide. Most jellyfish are more than 95 percent water, while we humans have a water content of only 65 percent.

anemone & clownfish

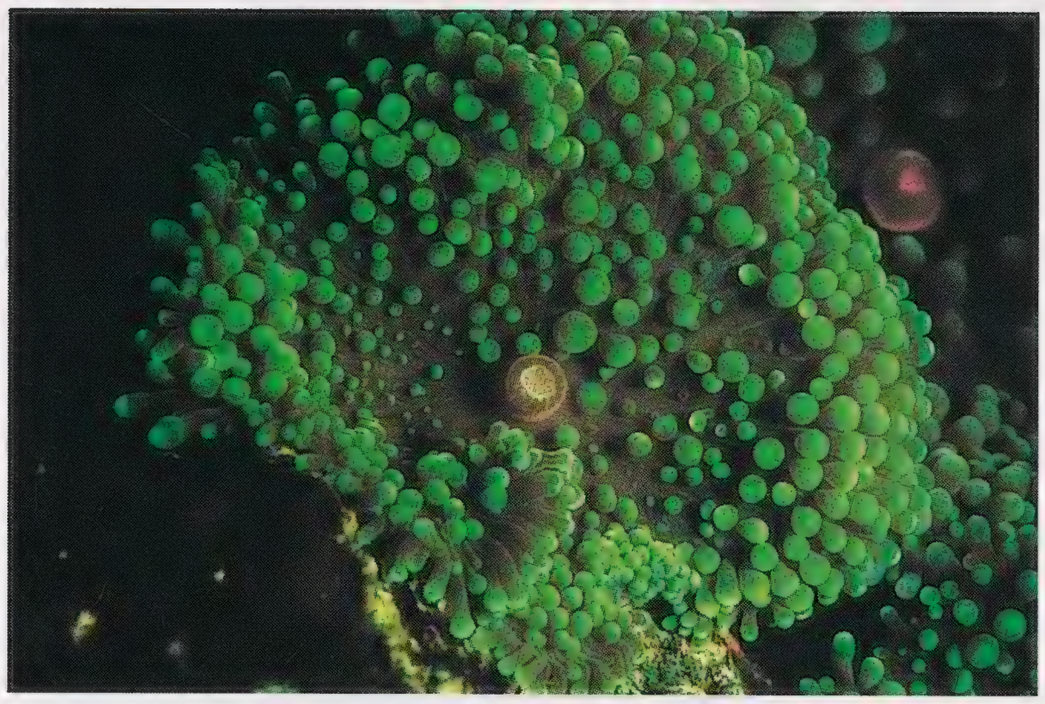
This tomato clownfish of the South Pacific can flaunt its vivid color thanks to its anemone protector's stinging tentacles, which deter predators. The clownfish is not harmed by the anemone because it secretes a chemical that keeps the anemone's stinging cells from firing. While being caressed by its guardian's tentacles, the clownfish serves its host by constantly removing debris. Other fish-invertebrate partnerships have been discovered by marine biologists and divers, including juvenile jack fish that live amid the tentacles of jellyfish, pipefish that weave their way through the wavy polyps of stinging mushroom coral, and pearlfishes that shelter inside sea cucumbers' body cavities.

Paul H. Humann

the marvelous majority

★ The hard corals are tiny colonial animals with bone-hard skeletons. Many generations of corals, layered one atop the other, form reefs, which often provide oases for species that could not otherwise survive in nutrient-poor tropical waters. Hard corals thrive in warm, shallow, clear waters, providing a substrate for anemones, soft corals, and

"My mistress' eyes are nothing like the sun;
Coral is far more red than her lips' red..."
—William Shakespeare, *Sonnet 130*



Jessie Cohen/NZP

hard coral

other invertebrates, which in turn draw small fish and their large predators. This undersea bounty also draws human attention. An estimated 10 percent of reefs have been destroyed due to coral mining for building materials, overfishing, tourism (damage by boat anchors and trampling snorkelers), and pollution. Australia's Great Barrier Reef, which stretches for more than 1,200 miles, forms the longest string of reefs in the world.

termite mOunds

The huge mounds built by some tropical termites have a profound effect on the landscape. For example, this photo shows how Tanzanian villagers built a lookout post on top of a termite mound so they could spot crop-raiding baboons. A variety of wildlife, including striped and dwarf mongooses, monitor lizards, and many birds, burrow into and live in the empty chambers in the mounds. Meanwhile, inside the nest, thousands of workers carry bits of grass from the surrounding savanna to serve as compost for the extensive fungus gardens that provide food for the colony.

Edward S. Ross

the marvelous majority

The silkworm is the only completely domesticated insect, and has been raised by humans for more than 4,000 years. Silkworms' cocoons are unwound to gather the precious threading, which is woven into fabric. The robe shown here is embroidered silk and linen, and was made for a Daoist priest. In the late 1800s, during a time when the silk industry was hard-hit by an epidemic, Etienne Leopold Trauvelot, a French scientist living in Massachusetts, tried to come up with disease-resistant moths that spun fine silk. He imported gypsy moths from France, and some escaped while he tested their viability for the market. This experiment resulted

The Textile Museum, Washington, D.C., (1976.26.8), gift of Jerome A. and Mary Jane Straka.

silk

the marvelous majority

in the plague of oak-munching caterpillars we still battle today, while silkworms remain uncontested as the finest silk spinners.

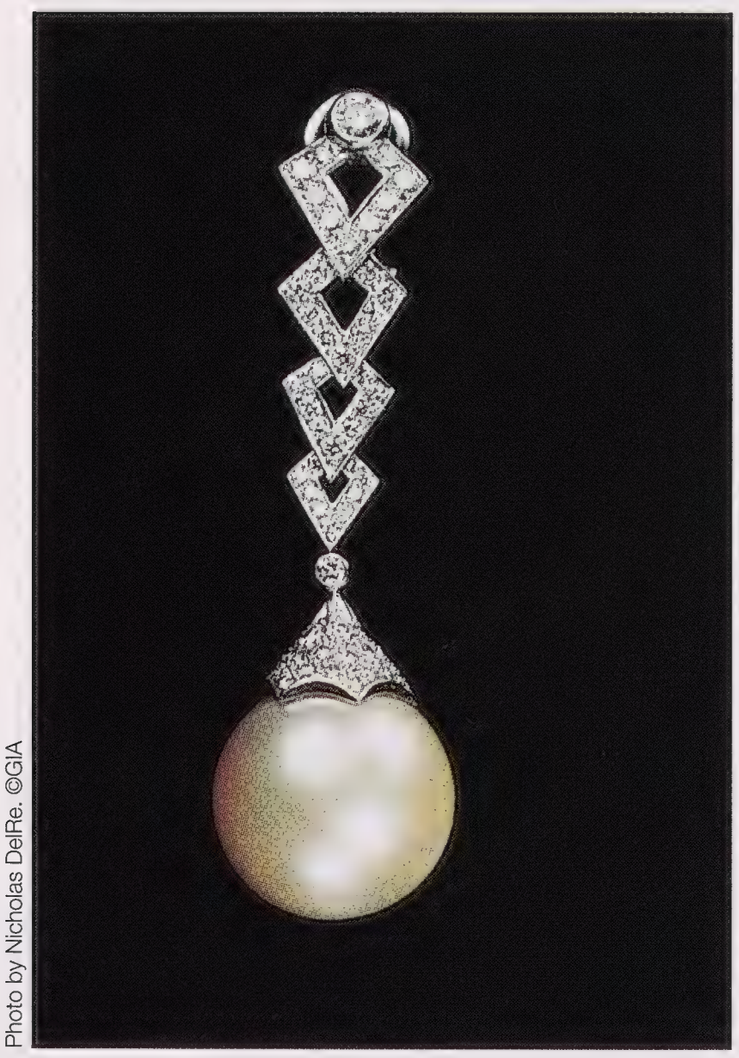


Photo by Nicholas DelRe. ©GIA

pearls

The treasured pearl is really a shellfish's effort to protect itself from a parasite or intruding particle. Pearl owners, then, wear this invader, which after becoming wedged between the oyster's shell and "skin" (mantle) was repeatedly covered with a pearly coating that protects the oyster's soft body. Most valuable pearls come from marine oysters, though many other species produce them. Oysters are often "cultured": people push bits of shell into the molluscs' mantles. The pearls are harvested more than five years later. Because moisture is captured between their pearly layers, pearls are susceptible to drying and cracking if not regularly worn close to moist skin.

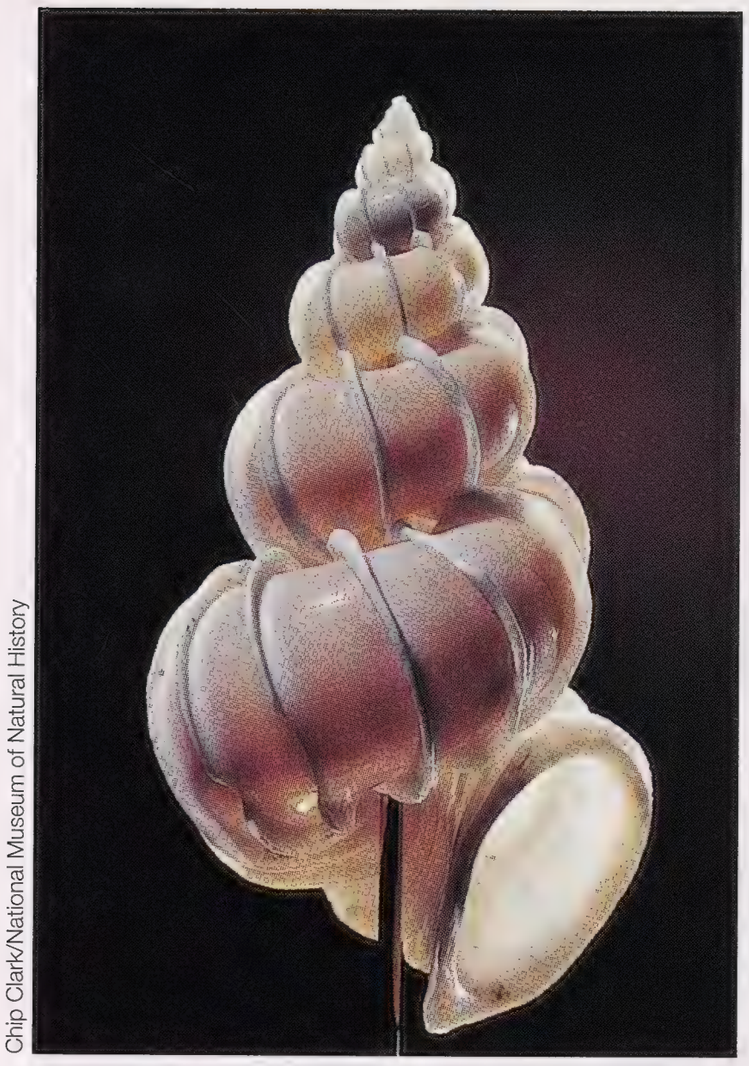
cowries

★ Shallow waters off Florida and the West Indies are home to the beautiful deer cowrie. Cowries are molluscs that occur mostly in the tropics, where their smooth, shiny shells are prized as ornaments, jewelry, money, or as a surface for carving. Pacific island royalty, for instance, wore the shells of the golden cowrie on their robes, and tribes in Africa and other tropical regions used shells of the money cowrie as currency. A live cowrie's skin-like mantle periodically extrudes and wraps around the animal's hard shell, keeping it clean while causing growth by depositing successive layers of calcium carbonate.

Jessie Cohen/NZP

invertebrates

Shells of more than 1,000 mollusc species can wash up on Atlantic shores, from the Caribbean to Canada. While most people may pick up a pretty shell they happen to find at the beach, there is a hard-core and growing group of shell collectors who scour beaches for new specimens to add to their well-documented collections. At least 30 well-established shell clubs, made up of both malacologists (those who study molluscs professionally) and amateurs, hold meetings in



Chip Clark/National Museum of Natural History

shells

different parts of the U.S. Most shell collectors would surely admire the rare specimen shown here. This stunning shell, which is on exhibit in the Smithsonian's National Museum of Natural History, represents one of many species of wentletraps, or staircase shells, prized by shell collectors for their smooth finish and spiral patterns.

One of the world's most successful businesses has always benefited from the shell. In 1830, Marcus Samuel began a trading business in London. As part of his business, Samuel imported polished sea shells from Asia, and sold screens, boxes, and other items decorated with them. When the family later became involved in the petroleum business and Marcus Samuel's sons founded a new company, they chose a shell as their symbol for sentimental reasons. In 1904, the nondescript shell they chose was changed to the scallop that is still used today to represent the Shell Oil Company.

Shell Oil Company

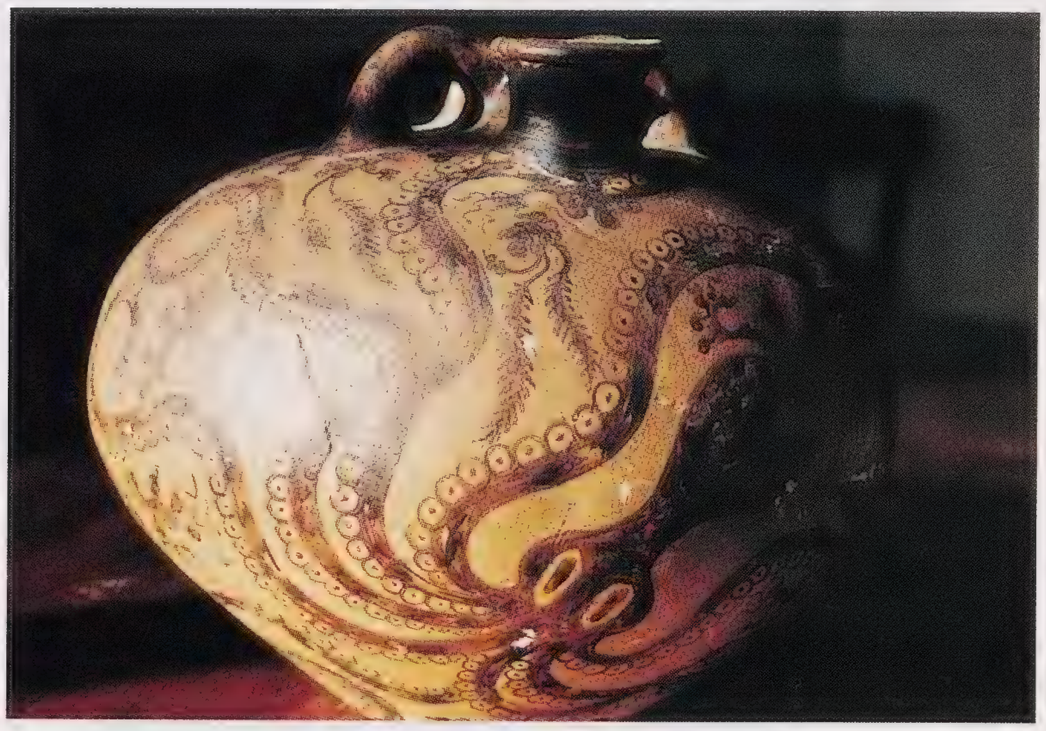
the marvelous majority

octopuses

★ This replica of a Minoan stirrup vase captures elements of the early styles used by that Aegean culture more than 3,000 years ago. Unlike many of these vases, which depict an octopus with six or fewer arms, this one shows a full complement of eight. Although the Minoans portrayed many sea creatures on their works, the octopus, a major part of the their diet, was the most popular by far. Over the years, the octopuses decorating the vessels degenerated into stylized depictions, later versions of which barely resemble an octopus.

"Adopt the character of the twisting octopus, which takes on the appearance of the nearby rock. Now follow in this direction, now turn a different hue."

—Theognis, c. 545 B.C.



Alex Hawes

the marvelous majority

cuttlefish

Jessie Cohen/NZP

★ An unsuspecting shrimp is locked on target by a cuttlefish at the Zoo's Invertebrate Exhibit. Two of the cuttlefish's 10 arms are modified graspers that shoot out at small prey. In a blink, the shrimp will be grabbed and pulled in to be devoured. Cuttlefish are quick-change artists, flashing different colors either for camouflage or for communication with others of their kind. The hard, gas-filled shell of the cuttlefish, long used as a "cuttlebone" for parakeets to chew on for calcium, may regulate the cephalopod's buoyancy. Cuttlefish are prized in Asia as a delicacy, as much as squid are relished in Italian cuisine, and their ink, known as sepia (Sepia is also the genus name for the most familiar cuttlefish), is used by artists.

crayfish

Jessie Cohen/NZP

★ Crayfish are small freshwater cousins of lobsters. Turn over stones in almost any local stream and you should find one. These crustaceans scavenge dead plant and animal matter, and also ambush small fish. When threatened, a crayfish quickly contracts its abdominal muscles, and propels itself backward, away from danger. Crayfish can migrate over land for short distances to move from one stream or pond to the next. The meaty tail muscles are widely eaten, and crayfish is commonly harvested as a second crop in the wet rice fields of Louisiana and east Texas.

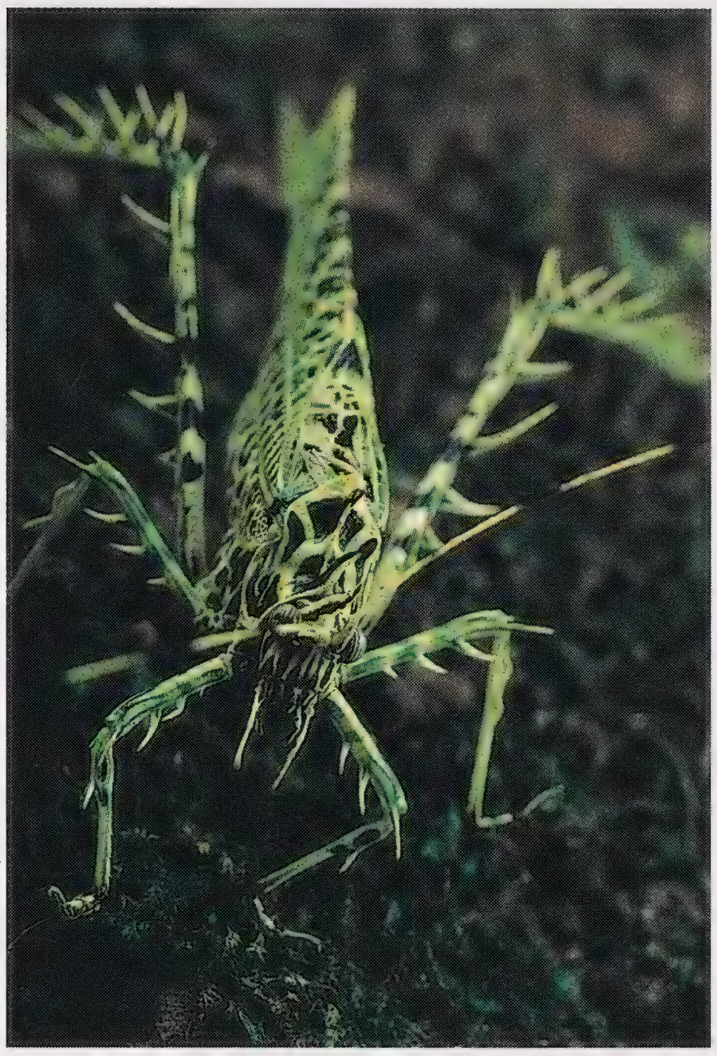
invertebrates

food

For some reason, when it comes to dining on invertebrates, Americans and Europeans focus mostly on those that dwell in the oceans. In our cuisines there are many uses for clams, oysters, mussels, scallops, lobsters, crab, shrimp, and squid. True, the French relish land snails, but what about the many insects we regularly see? Why not grubs, crickets, or katydids? People in other parts of the world dine on invertebrates

Edward S. Ross

often unfamiliar to most of our palettes. The Thai vendor shown here, for instance, is selling giant water bugs, which buyers will pulverize into a paste used as a condiment for rice and vegetable dishes.



Rob & Melissa Simpson

katydids

Many katydids resemble the leaves they eat. Others have even more complex camouflage, like this species, which blends remarkably well with the stringy lichens common in its cloudforest home in Costa Rica. Katydids are active and noisy mainly at night. They are named after an imitation of the call of a widespread species. Katydids are also called longhorn grasshoppers, a name that reflects their close relation and resemblance to grasshoppers and crickets.

treehoppers

Treehoppers come in many forms. This thorny treehopper is one of a group of small arboreal insects that use their hump-like backs and cryptically colored bodies as camouflage.

Chip Clark/National Museum of Natural History

Michael H. Robinson

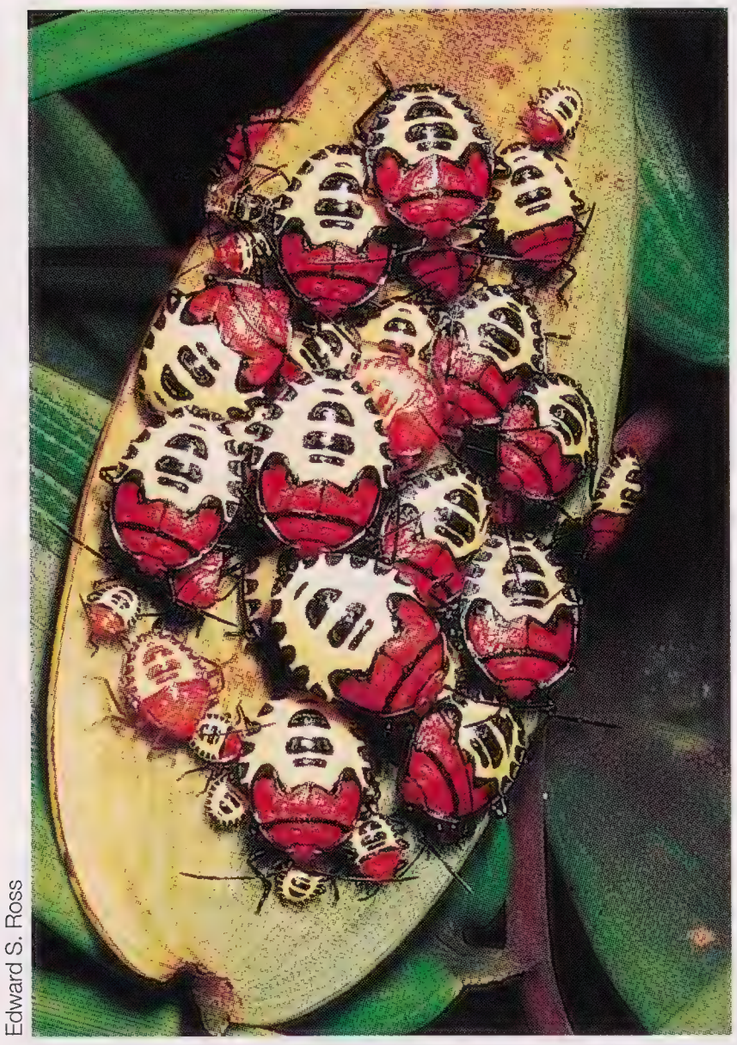
leaf insects

The uncanny camouflage of this leaf insect (*Phyllium* sp.) hides the tropical stick-insect relative in its Papua New Guinea forest home. Many insects employ similar camouflage tactics to avoid being eaten by birds, lizards, and other predators.

the marvelous majority

"Yet let me flap this bug with gilded wings,
This painted child of dirt, that stinks and sings."

—Alexander Pope, *Epistle to the Earl of Oxford and Earl Mortimer*



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These gaudy bugs are more than obvious to prospective predators, which would likely find them unpleasant, or dangerous, to eat. Because of offensive fluids issuing from the spots on these pentatomids' backs, they are called "stink bugs." Clumping intensifies these brightly colored insects' warning—one bug makes a stink, but many bugs make a big stink! The clump shown here includes various immature stages, which began clumping as soon as they hatched from a batch of eggs. The adults have wings and can fly when disturbed.

the marvelous majority

stink bugs

"I would not enter on my list of friends
(Th'o grac'd with polish'd manners and fine sense,
Yet wanting sensibility) the man
Who needlessly sets foot upon a worm."

—William Cowper, *Tirocinium*

flatworms

invertebrates

Although many flatworms (planarians) live in water, some, such as this large Brazilian species, ooze their way over damp land habitats, constantly changing shape. They feed by pressing small creatures between their slimy skin and the ground, then sucking parts of their prey up through a tube-like apparatus that feeds into the mouth, which is located in the middle of the planarian's underside. The bright color of this species suggests that it is advertising itself as something unpleasant to eat.

Edward S. Ross

Jessie Cohen/NZP

featherduster worms

★ Tethered to rock or another substrate, the hard stalk of the featherduster worm provides a tough sheath from which the soft-bodied worm can extend its feathery tentacles, which are used for both respiration and feeding on passing particles.

invertebrates

★ Each May, horseshoe crabs haul onto Atlantic coast beaches by the thousands to lay their eggs. Males tag along behind the females, depositing sperm on the thousands of eggs each female lays. In turn, flocks of migrating shorebirds and gulls descend upon the mating couples to gorge on the bounty of fresh eggs. Horseshoe crabs are not true crabs, but spider and scorpion relatives. They have remained virtually identical in appearance and size to ancestors that swam in shallow waters 400 million years ago. These odd animals often swim upside-down, and when they get stuck upside down in shallow water or on land, they flip themselves over with their dagger-like tails. Medical researchers use the animals' lysate, a fluid from their broken blood cells, to test for the presence of bacteria and other contaminants in pharmaceutical products.

horseshoe crabs

Rob & Melissa Simpson

"I should have been a pair of ragged claws
Scuttling across the floor of silent seas."

—T.S. Eliot, *Macavity: The Mystery Cat*

the marvelous majority

blue crabs

Think of the Chesapeake Bay, and visions of steaming crab cakes may come to mind. About half of the United States' catch of blue crabs comes from the Chesapeake. For blue crab lovers, however, the news is sad these days. Since 1990, blue crab populations have dropped almost 35 percent, and, on the Potomac, numbers fell by about 33 percent between 1994 and 1995. Following recent crashes in oyster and fish catches, many fishermen have turned full attention to blue crabs, which breed near the mouth of the Bay but migrate north seasonally. Scientists too have focused on crabs. The crab shown here was fitted

the marvelous majority

Kirsten Elstner

with transmitters to monitor its movements in and around the Bay. Virginia and Maryland have revised harvest regulations to protect the dwindling populations of this crustacean. Blue crabs are found in salty and brackish waters from Canada south to Argentina.

trilobites

Long before the dinosaurs, trilobites roamed the seas in abundance. Today they exist only in books and as fossils. These sea scavengers probably sought out dead or stationary plant and animal matter. Around 10,000 trilobite species have been described from fossils. Their demise likely followed the rise of predatory animals like cephalopods and fish. This fossilized trilobite shows how these prehistoric arthropods got their name, which means "three lobes." Two ridges divide the body into three lengthwise sections.

Chip Clark/National Museum of Natural History

invertebrates

Endangered Invertebrates

Although the most plentiful creatures on earth are invertebrates, not all species of spineless creatures are abundant. In fact, some are endangered. The U.S. Fish & Wildlife Service lists 105 U.S. species and subspecies of snails, clams, crustaceans, insects, and arachnids as endangered, and 25 more as threatened. Many are threatened by habitat destruction, including the California freshwater shrimp, a small crustacean that has declined after streamside vegetation was removed by livestock grazing, and erosion clouded the stream waters in which it lives. School children have been instrumental in trying to save this species, raising money and public awareness, and working with farmers to replant some of the native plants lost from the shrimps' remaining hideaways.

invertebrates

Chip Clark/National Museum of Natural History

amber

Insects and plants entombed in golden amber—a fossil tree resin—provide scientists with glimpses of small organisms that lived millions of years ago. Gem collectors also prize pieces of this substance. Although found in many parts of the world, the most significant amber deposits have been unearthed around the Baltic Sea, in 40- to 60-million-year-old sands.

A dragonfly is one of many animals Pueblo Indians etched into the basalt boulders in and around what is now Petroglyph National Monument in New Mexico. This image of a dragonfly was most likely engraved in the rock between 1300 and 1680. Dragonflies have long been prominent flying insects—in fact, they appeared well before dinosaurs. Giant dragonflies—the largest insects ever known—swooped over marshes 250 million years ago. Some species, like one represented by a life-sized model at the Invertebrate Exhibit, had wingspreads of about 28 inches.

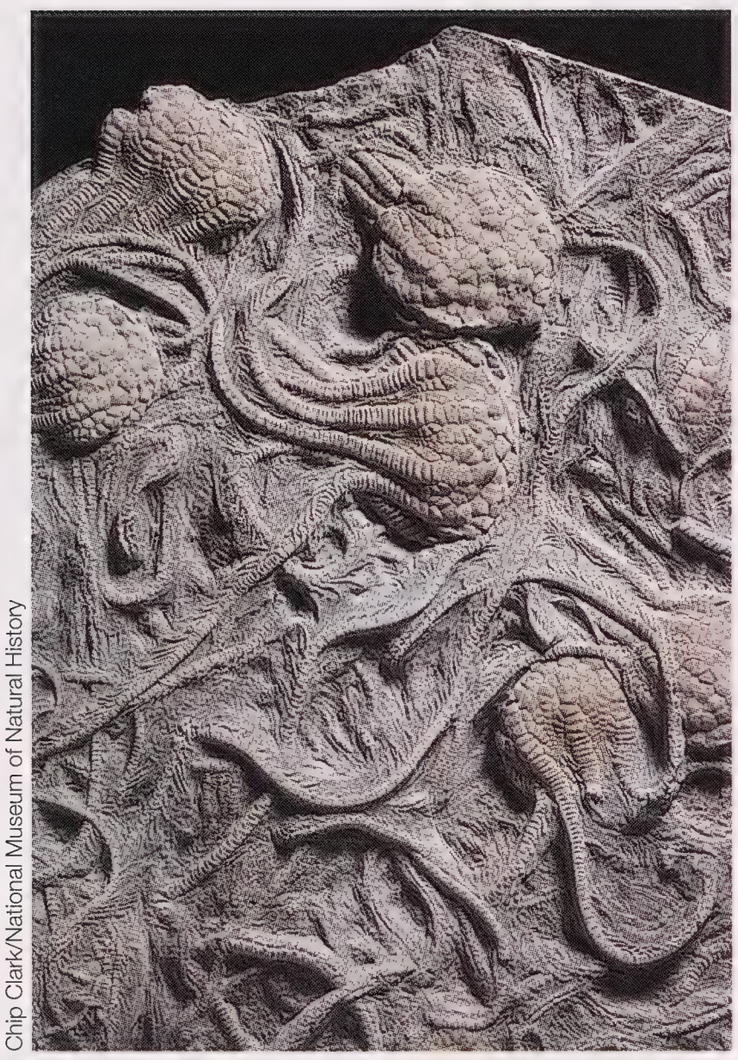
dragonflies

John Seidensticker

"Deep in the sun-searched sky growths the dragon-fly
Hangs like a blue thread loosened from the sky:
So this wing'd hour is dropt to us from above.
Oh! clasp we to our hearts, for deathless dower,
This close-companioned inarticulate hour
When twofold silence was the song of love."

—Dante Gabriel Rossetti, *The Choice*

the marvelous majority


Chip Clark/National Museum of Natural History

Sea lilies, like most echinoderms—a phylum of spiny-skinned marine animals—at first sight defy our perception of what is animal. These fossilized sea lilies, on exhibit at the National Museum of Natural History, have been dated at 330 million years old. Sea lilies thrived in ancient seas, such as the waters that once covered Iowa and Indiana, where this fossil was found. Today, however, the few species that still survive are found only in deep water. Sea lilies superficially resemble flowers: They spend their lives attached to a fixed location by a longish stalk, their petal-like arms waving in the current, gleaning food particles from the water and drawing them back toward the animal's mouth. Other echinoderms, including urchins, sea cucumbers, and sea stars, are common in shallow coastal waters as well as deep seas.

sea lilies

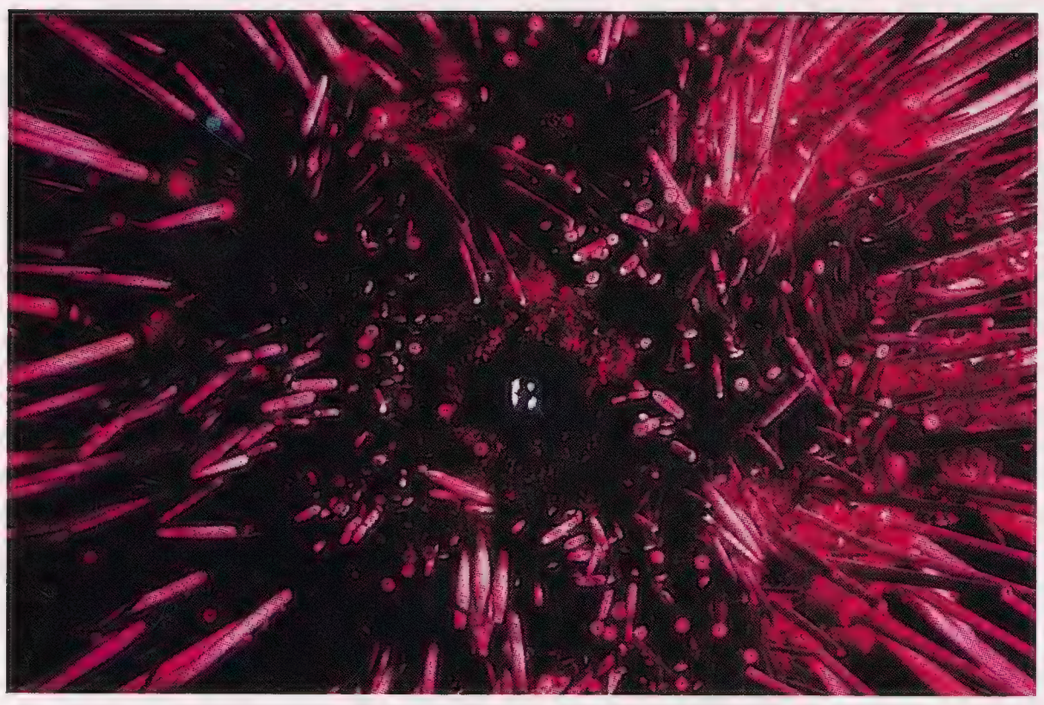
the marvelous majority

★ Sea stars scavenge, usually in shallow waters, and hunt slow-moving or stationary animals like clams and oysters. This sunflower star from the Pacific coast is one of about 2,000 sea star (or starfish) species. Sunflower stars can grow more than 20 arms and reach two feet in length. Some sea stars feed on clams and other bivalves, grasping them with sucker-studded tube feet and prying their shells open. Once a sea star has pried the bivalve's shell open just enough, it extrudes its stomach within the hapless animal's shell and digests the victim's insides.

Jessie Cohen/NZP

sea stars

invertebrates



Jessie Cohen/NZP

★ Cloaked in spikes set into large, hardened plates, sea urchins look more like medieval weapons than marine animals. Despite their armor, they fall prey to sea stars and other predators. The urchin's armor, called a test, encloses and protects the animal's soft organs, including the large gonads, which people in many parts of the world eat as a delicacy. Urchin populations can be both explosive and implosive, with wild fluctuations in numbers sometimes telling of environmental imbalance. For instance, there have been dramatic rises in urchin numbers following overhunting of lobsters and sea otters, two urchin predators. Conversely, die-offs sometimes occur, possibly due to environmental changes that may leave urchins more vulnerable to disease.

sea urchins

invertebrates

Invertebrates have inspired many writers through the years and have been featured in many works, some fantastic, others dreary. Franz Kafka's stirring *Metamorphosis* describes a young man's inner strife, illustrated through his transformation into an insect that falls and lies helpless on its back. *Charlotte's Web's* heroine, a barn spider, saves a talented pig from slaughter by writing messages in her web. Another web-slinging hero, Spiderman snuffs out crime in the big city. In the children's book *Newberry: The Life and Times of a Maine Clam*, a clam with a neck ache dons a purple scarf and sets off on a wild adventure that highlights the real plight of clams and the dangers they face, from predation by gulls and starfish to pollution.

invertebrate fiction

Down East Books

the marvelous majority

"Dar'st thou die?
The sense of death is most in apprehension,
And the poor beetle, that we tread upon,
In corporal sufferance finds a pang as great
As when a giant dies."

—William Shakespeare, *Measure for Measure*

© 1984. The Metropolitan Museum of Art, bequest of Laura Frances Hearn, 1917 (17.101.55). Photo by Bob Hanson.

beetles

The order Coleoptera, insects better known as beetles, constitutes a third of all known insect species (about 300,000 in all). In the 1800s a watchmaker was inspired to fashion this elegant timepiece in the shape of a beetle (perhaps a ladybug), complete with movable wings that protect the watch beneath.

"The ant's a centaur in his dragon world."

—Ezra Pound, *Homage to Sextus Prospertius*

ants

As few as 30 stings from Australia's venomous bulldog ant can kill a human. The sting of just one of these large ants hurts at least as much as a wasp sting. Bulldog ants aggressively defend their ground nests, and reportedly will scurry and jump toward intruders.

Edward S. Ross

invertebrates

the marvelous majority

Edward S. Ross

Each year, about two million people die of malaria, a disease transmitted into the bloodstream by female *Anopheles* mosquitoes, which cannot produce eggs without blood. Malaria was once much more widespread, even occurring as far north as Russia and the northeastern U.S.

mosquitoes

Changes in drainage and construction techniques (including screening windows), and effective treatment of cases, helped eradicate the disease in many areas. Other diseases spread by mosquitoes include yellow fever and dengue fever, which are spread by mosquitoes in the genus *Aedes*. An *Aedes* mosquito is pictured here.

the marvelous majority

At very close range, the giant hornet appears as bizarre and beautiful as any science fiction creation. Three simple eyes, which are sensitive to light, can be seen toward the top of the head, while thousands of facets make up the two black, image-producing compound eyes. The hornet chews up other insects with its strong mandibles.

Rob Simpson

hornets

Insects are the world's most diverse group of animals, totaling about 930,000 described species, and many new species continue to be found as scientists study both local and remote areas more thoroughly. (Compare that with the approximately 4,600 described mammal and 9,600 bird species.)

NBA Properties, Inc.

Humans have both revered and loathed these ubiquitous animals, and today they feature prominently in many areas of our culture, including professional sports. Though many teams have chosen large animals to signify prowess and power, the Charlotte Hornets chose a diminutive but mighty mascot, one that certainly commands respect.

invertebrates

Edward S. Ross

mantises

The predatory mantises are often lauded as beneficial pest hunters, but in truth they are indiscriminate killers. These sit-and-wait predators are usually colored to match their leafy or twiggy surroundings, and lash out with their barbed forelegs at passing prey. Occasionally, females attack and feed on their mates, and both sexes kill beneficial as well as harmful insects, along with a variety of other small creatures—even, rarely, hummingbirds.

invertebrates

centipedes

In spite of the meaning of their name ("hundred feet"), some centipedes have more than a hundred legs, some fewer. Unlike the sluggish millipedes, which mostly eat decaying vegetation, centipedes are fast-moving hunters, armed with biting, poison "jaws" that are actually modified legs. During its fast-paced life, a centipede may lose some legs either chasing prey or avoiding predators. Lost legs are replaced during periodic molts. This large species was photographed in Namibia.

Edward S. Ross

the marvelous majority

"My father has chastised you with whips, but I will chastise you with scorpions."

—1 Kings, 12:11

Edward S. Ross

scorpions

★ Scorpions give birth to live young, which clamber onto their mother's back, sharing the insects and other small animals she kills until they can fend for themselves. Most scorpions are capable of painful stings, though few are deadly to humans. Their crab-like claws grasp prey, while

the stingers do the killing. Once a meal is secured, a tiny pair of claws by the scorpion's mouth tears food into smaller pieces. In North America, scorpions are most common in desert areas, where they are hunted by bats, owls, and other predators. The species shown here inhabits the savannas of Tanzania.

Michael H. Robinson

This jumping spider feeds on a cricket it captured not in a web, but by ambush. Jumping spiders, with about 4,000 species, make up the world's largest family of spiders. Their unusually large eyes enable them to sight prey and pounce. This jumping spider was photographed in Panama, but many species are found in temperate areas, including Washington, D.C.

"Experience is never limited, and it is never complete; it is an immense sensibility, a kind of huge spider-web of the finest silken threads suspended in the chamber of consciousness, and catching every air-borne particle in its tissue."

—Henry James, Prefaces

★ In many spider species, females are much larger than males. The greatest size difference occurs in the genus *Nephila*, including the species shown here. Females of some species can weigh more than a thousand times as much as males, a size difference the male uses to his advantage when it comes time for mating. A male's tiny size draws little interest from the beefy female, which targets larger prey, so the male can wander near her and mate with impunity, while males in other genera must use various tactics near their ever-vigilant prospective mates to avoid becoming a meal.

Michael H. Robinson

further reading

For those thirsting for further invertebrate information, the Zoo Bookstore may have the book for you. Below are four suggestions for further reading, all available at the Zoo.

The Encyclopedia of Land Invertebrate Behaviour. 1993. Rod and Ken Preston-Mafham. MIT Press. 320 pp. hardbound, $45.00.

The Preston-Mafham brothers—Rod, a biologist, and Ken, an eminent wildlife photographer—take a look at the mating, egg-laying, parental, feeding, and defensive behaviors of terrestrial invertebrates. Not an all-encompassing textbook, *The Encyclopedia of Land Invertebrate Behaviour* focuses on certain of the more interesting and bizarre examples of invertebrate behavior—such as the mating ritual of male dance flies, who bestow petals wrapped in silk as nuptial gifts to potential mates. Such examples are accompanied by the authors' wonderful photographs.

Spiders of the World. 1984. Rod and Ken Preston-Mafham. Blandford Press. 191 pp. hardbound, $24.95.

The Preston-Mafham brothers strike again, this time focusing on one of the public enemies of the invertebrate world: the spider. This brief overview, part of a Facts on File series, delves into spider strategies the world over, as well as spider anatomy and evolution, and spiders' relationship with humankind. The authors hope that learning about the daily grind of spiders' lives may help cure, for some, the arachnophobia seemingly innate in humans. The Preston-Mafhams illustrate the text with striking photography.

Insects of the World. 1984. Anthony Wootton. Blandford Press. 224 pp. hardbound, $17.95.

Also part of the Facts on File series, this volume follows the same general format as *Spiders of the World*. Wootton investigates, in a fairly non-technical manner, the origins and distribution of insects, and how representatives from the wide array of insect species go about communicating with each other, feeding, reproducing, and defending themselves. Humans' relationship with insects also is explored. Excellent color and black-and-white photography expose the reader to the beauty and novelty of the insect world.

Journey to the Ants: A Story of Scientific Exploration. 1994. Bert Holldobler and Edward O. Wilson. Bellknap/Harvard. 228 pp. softbound, $16.95; hardbound, $24.95.

invertebrates

Authors of the Pulitzer Prize-winning monograph, *The Ants*, Holldobler and Wilson present their decades of research on ant behavior in a much less technical way. One scientist estimated that there may be ten trillion ants crawling the earth at any given time. This book explores the remarkable diversity of the thousands of ant species, and the power of ant cooperative societies, or "superorganisms." Wilson spent his early childhood in Washington, D.C., and was inspired to entomology by his explorations of the micro-fauna of Rock Creek Valley.

—Alex Hawes

Edward S. Ross

the marvelous majority

notes & news

CATERPILLAR CRAWL & BUTTERFLY FEST

In May, FONZ will hold two very different fundraising celebrations: Caterpillar Crawl takes place Friday, May 10, from 6 p.m. to 8 p.m. This family-oriented event features a carnival atmosphere of clowns, hotdogs, and ice cream, with arcade games, karate demonstrations, storytellers, dancers, and a toddler play area. Tickets for both kids and adults cost $15 for the general public and $12 for FONZ members. Proceeds go to education programs at the National Zoo.

Jessie Cohen/NZP

Butterfly Fest, a gala event for adults, will be held Thursday, May 16, from 6:30 p.m. to 11 p.m. The Zoo will sparkle with light and live entertainment provided by The Spinners, as a hundred of the area's finest restaurants serve their fare. A sweepstakes, silent auction, and animal demonstrations will round out this memorable gala. Tickets are $95 for members ($70 of which is tax deductible) and $115 for the general public ($90 of which is tax deductible). Tables for ten can be reserved for $1,500 ($1,250 of which is tax deductible). A table for 10 hosted by a Zoologist, who will conduct a behind-the-scenes tour of her or his area, is $2,000 ($1,750 of which is tax deductible).

Butterfly Fest is generously underwritten by W*USA-TV (Channel 9), MIX 107.3-FM, Black Entertainment Television, The Coca-Cola Company, E.U. Services, Kodak, and the Purina Cares Fund. Proceeds from the event benefit the Zoo's Theodore H. Reed Animal Fund, with money earmarked for conservation, education, and BioPark exhibit programs at the National Zoo. Call 202.673.4961 for tickets and information.

CALL FOR VOLUNTEERS

The Friends of the National Zoo Wildlife Art Festival has quickly become one of FONZ's largest events. FONZ is seeking enthusiastic, creative volunteers to manage committees that will be involved in the planning, setup, and operation of the 1996 Friends of the National Zoo Wildlife Art Festival, which begins Friday night, September 20, with a special preview party and auction; the two-day art show will be held Saturday and Sunday, September 21 and 22. These managerial positions will involve daytime commitments. The ideal candidates interact well with people, are detail-oriented, and can work in a highly charged, fast-paced environment. Computer literacy is a plus. As the Festival approaches, time commitments listed below will increase and flexibility will become all the more important. The five committee positions (and approximate time commitments) are outlined below:

Creation Station: Organize classes developed by volunteer elementary school teachers; solicit donations for supplies; schedule classes and set up registration (when applicable); work with FONZ staff to set up displays, signage, and location layout; oversee activities during the Festival weekend. (One to two days a week.)

Demonstrations and Lectures Liaison: Solicit participation from exhibiting artists and lecturers. Work with FONZ staff to set up demonstration and lecture areas. Act as a liaison between FONZ staff and speakers to provide supplies and other necessary materials for talks. Must be available throughout the Festival weekend to provide speaker support, solve problems, and anticipate last-minute details. (One day a week.)

Preview Party Liaison: Act as a liaison between caterers and FONZ food service staff. Work with FONZ staff to arrange music and develop logistics for the party. Develop mailing lists, work with invitation designers and printers, and organize reservations and ticket distribution. Oversee the party Friday, September 20, and work closely with auction manager. (Begin in July; one day a week; no responsibilities after Friday, September 20.)

Auction Liaison: Arrange for auctioneer; oversee display of auction items; work with FONZ staff to develop the auction catalogue; act as liaison with artists donating auction pieces. (One to two days every other week; no responsibilities after Friday, September 20.)

Special Guest Liaison: Work with FONZ staff to coordinate and solve problems relating to the setup and implementation of behind-the-scenes tours for guests and featured artists; be available during the weekend to solve problems faced by special guests (for example, dinner or room reservations). (One day every two weeks and a commitment during the entire Festival.)

For additional information, and to set up an interview for any of the above positions, please call Terry Lubar in the FONZ Membership Office at 202.673.4961.

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CATERPILLAR CRAWL

ZooFari for Kids
To Benefit the National Zoo
May 10, 1996
6 p.m. to 8 p.m.

BUTTERFLY FEST

National ZooFari
To Benefit the National Zoo
May 16, 1996
6:30 p.m. to 11 p.m.

Call 202.673.4961 for tickets and information.

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